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Student-Centered Collaborative Classrooms and Critical Thinking Skills

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Abstract

The purpose of this action research was to determine if implementing a student-centered, collaborative classroom would have a positive effect on student critical thinking and problem-solving skills. Data was collected at six points during the study. Three set were collected prior to the intervention and three sets were collected after. After analyzing the data, the research suggests that students working in peer collaborative groups can have a positive impact of their problem-solving strategies and improve their critical thinking skills.

Keywords: collaboration, critical thinking, student-centered, problem-solving

Student-Centered Collaborative Classrooms and Critical Thinking Skills

Education is always evolving because the world is always changing. The work environment, social environment, and the overall way we live has had significant changes in the last several years. Education has also changed to keep up with the ever-changing world. Teachers have a great responsibility to prepare students for careers that do not even exist in a changing world. There are always new ideas and strategies to use in the classroom however, there is not always a lot of research showing the effects of some of the newest information. Teachers work to improve student learning using some of the new approaches that have little research to prove their effectiveness and they often do their own research as they are trying something with their students.

One such approach is student-centered classrooms. Research shows that student-centered classrooms can have a positive impact on student growth. In a student-centered classroom the role of teacher and student have been redefined. The teacher provides guidance in a facilitator role rather than as a lecturer. Students take more ownership of what and how they learn which has shown increased student achievement. This is in contrast to a traditional classroom where teachers transmit information for their students to memorize. Students receive instead of create their learning. Student-centered classrooms allow teachers to scaffold content and learning which will help students to become increasingly independent.

In the working world, teams have been effective and improved production in companies. Students working in collaborative teams have shown to have a positive effect as well. Students can improve communication skills and deepen their understanding of content when they are asked to work and share with a group of their peers. In this situation students are both teachers and learners. They each contribute to their group and receive information from each other. They

work collectively to solve problems and share their strategies. Peer groups can set up norms and participation rules to facilitate their collaborative learning and create a sense of community within their group. The role of the teacher has again changed to fit the needs of student collaborative groups. They are tasked with improving student achievement using multiple and differentiated strategies and often serve students in a facilitation role instead of a transmitter of content. Through questioning they guide students in their exploration.

Teachers also have the task of helping their students learn how to think, not what to think and develop a deep understanding of the content. Developing students' higher order thinking skills has shown to increase student achievement. Teachers in traditional classrooms transmitted information that students stored and recalled when necessary. Bloom's Taxonomy has placed a higher importance on skills such as, creating, evaluating, analyzing, and understanding, which are skills that require students to think not recall information. Teachers have the task of helping students develop these skills which they will throughout their lives. Using these skills can help students address real world problem and persevere in solving them. Developing these skills can help prepare students for the ever-changing global environment they will be working in.

Knowing what students need to know and be able to do: will implementing a student-centered, collaborative classroom improve students' problem-solving and critical thinking skills? Students need to have a toolbox of strategies to use when they are solving problems and have a deep understanding of the concepts they are working with. Working in a group of peers on real-world problems can improve critical thinking skills and have a positive impact on student achievement. As students learn to work in peer groups and increase the strategies they can use to solve mathematical problems, they can also increase their capacity to use mental math and can focus more on the content of real-world problems. Teachers want their students to be prepared

for life beyond school and achieve at the highest possible level. This action research paper will show if a student-centered collaborative classroom can have a positive effect on student learning and help students develop a deep connection to the content.

Review of the Literature

Piaget's Cognitive Theory says that children construct their own knowledge of the world and that knowledge changes, as they grow and develop, into something more sophisticated. One cannot talk about scaffolding without Vygotsky's Social Development Theory. His theory has three components: social interaction, More Knowledgeable Other (MKO) and Zone of Proximal Development (ZPD). Both of these men, although they did not have the same ideas, play a large role in what is done in education still today. Student-centered classrooms have been based on the concepts of students constructing their own knowledge and teachers providing scaffolding at their students' ZPD to allow all students to make sense of the learning. In student-centered classrooms, students are more invested in and responsible for their learning. Students develop ownership over the process of acquiring knowledge. Students set learning goals. They work collaboratively with peers and each contribute to the group with the background knowledge and expertise that they have. There are several theories, in addition to the two previously mentioned, that have been associated with student-centered classrooms. Some of those theories include constructivist and constructionist and self-determination theories. Constructivist Theory and Constructionist Theory are similar in that they both state that students construct their own knowledge. Self-Determination Theory refers to autonomous learning and intrinsic motivation to learn. Through these theories, Lee and Hannafin (2016) have developed a framework where students not only develop ownership of their own learning, but also learn autonomously with strategic scaffolding and generate artifacts for authentic audiences.

The teacher serves in a role of a facilitator and provides the scaffolding to help students make sense of the problem. There is some dispute on how much support teachers should give students however, it is accepted that teachers should support student learning. Various research has defined scaffolding as ongoing diagnosis, contingency or responsiveness, fading, and transfer of responsibility (Calder, 2015). The intention of scaffolding is that students will eventually be able to work independently on the activity, therefore scaffolding is appropriate and temporary help (Calder, 2015). Scaffolding allows all students to actively engage in the work no matter what their level of understanding is. It gives students a point of access to be able to engage with the content and learn.

Student-Centered Classroom Defined

There are many different definitions for what a student-centered classroom looks like. Some of the commonalities include: identifying students as the owners of their learning, constructivist, cooperative, and the teacher fulfilling a facilitator role (Lee & Hannafin, 2016;Ding & Li, 2014). Communication is also a key factor in developing a successful student-centered classroom. There are also many variances of a student-centered classroom. Calder defines it as; "a deliberate, purposeful support of parts of a process or activity that the learner cannot undertake independently. The supports enable the learner to cognitively engage with the full process or activity" (Calder, 2015, p. 1121). Teachers guide the student learning with questions as opposed to giving them the information.

There are also critics of student-centered classrooms who have concerns about students' cognitive overload and therefore argue for direct instruction from teachers (Ding & Li, 2014). Direct instruction is defined as; "providing information that fully explains the concepts and procedures that students are required to learn and giving them the strategies to learn it," (Ding &

Li, 2014, p. 355). Some facilitation instead of direct instruction has produced low level exploration by students. Research tells us that direct instruction can address highly structured, well defined problems but that students should be prepared for real world problems which are less structured (Lee & Hannafin, 2016) thus, arguing the case for facilitation. Also, if students do not have background knowledge to use, misconceptions and assumptions can occur. Not having the background knowledge can also make students become frustrated and apply less effort. Direct instruction from teachers supports activating students' existing knowledge. Research also says that students have difficulty self-monitoring, managing their time, and asking for help when they need it (Lee & Hannafin, 2016). One idea is to combine direct instruction and student-centered facilitation. Some critics have suggested blending the two types of learning. Blending both direct instruction and facilitating student learning has also been researched as an alternative to one or the other. With this blended approach teachers would make the instructional decisions and give students an opportunity to explore. The two approaches would work together instead of competing with one another. Blending the two would reduce the cognitive overload on students and allow them to focus on the new content and the exploration.

Characteristics of a student-centered classroom. Traditional classrooms have several characteristics that will be discussed and then compared to student-centered classrooms. Traditional classrooms have long required students to learn from direct instruction provided by the teacher. Students are compliant during the receiving of the instruction and often asked to store and then recall the information (Lee & Hannafin, 2016). Teachers provide the objective or learning goals, choose the resources for the content, provide the learning context, and assess student learning. It can be said that the teacher transmits information and the students receive it.

With a student-centered classroom, the traditional roles have changed. Students are no longer receiving information but exploring and constructing it. Students work collaboratively to solve problems and use critical thinking skills to make decisions and to make sense of the content. The learning is scaffolded and more flexible. Students are the knowledge constructors and teachers are the facilitators (Lee & Hannafin, 2016). Most of the information comes from student exploration. Thinking about the mathematical practices standards, student-centered classrooms allow students to think and struggle and fail. Great learning comes when students are allowed to try, fail, and encouraged to try again.

Implementation of a student-centered classroom. Teachers serve as facilitators of learning in student-centered classrooms but that does not mean that they sit back and observe. They need to be able to ask guiding questions and be flexible with how the students are using the information and learning. Teachers can provide prompts that will help all students to be able to engage in the learning. They need to have good relationships with their students and promote student relationships with each other. Teachers also need to communicate the rationale of the learning. When students feel that there is a purpose to the learning they are more likely to be engaged (Lee & Hannafin, 2016). Teachers are very important in helping students develop the desire to learn. If a teacher is not excited about the learning that is going to happen, their students will not be either. Teachers need to help students set goals for their own learning and use questioning and scaffolding to help them get there. Scaffolding is described by Calder as; "deliberate, transitory, responsive support" (Calder, 2015, p. 1121). Some of the scaffolding that can be utilized by teachers include: "expert modeling, questioning, peer feedback, step-by-step checkpoints to support progress monitoring, and reflection" (Lee & Hannafin, 2016, p. 726). In math instruction, it is usually used to help students understand and use mathematical processes or

problem-solving strategies (Calder, 2015). Scaffolding can be from student to student or teacher to student in one on one or whole group situations. It is designed to be decreased so students can become independent over time.

Using new ways to teach and help students learn can be challenging for teachers to implement. Teachers need support to make the changes they need to their instruction and their classrooms. Often times, teachers are ill-trained to implement new ideas. Without training teachers cannot implement a student-centered classroom well. Teachers can even give up and revert back to their direct instruction without having the support that they need. Some criticisms of student-centered classrooms are that the teacher does not use their expert knowledge to instruct students and teachers are not preparing students for standardized tests.

Student Collaboration

Innovation, collaboration, and system thinking are increasingly recognized as skills that can be useful to children, and that can help ensure their successes as citizens and workers in the 21st century (Fahnstrom, Prygrocki, & McLeish, 2009). With student collaboration, students work together to solve problems and learn from each other in the process. When adults work together, they can solve problems more effectively, produce better products, and efficiently use their time. The same can be applied to our learners in schools. Working together they are able to solve problems more effectively, produce better projects, and use their time wisely. "Collaborative interactions are beneficial for tasks measuring visual perception, problem-solving and rule-based thinking" (Sills, Rowse, & Emerson, 2016, p. 313).

Research has shown that collaboration is particularly beneficial for lower-ability children when there is an ability asymmetry (Sills, Rowse, & Emerson, 2016). As the world becomes more complex, students will need to direct their own learning, communicate well, and work with

people from diverse backgrounds and views, and develop ways of dealing with complex issues and problems that require different kinds of expertise and background knowledge (Bielaczyc & Collins, 1999). Piaget and Vygotsky both viewed collaboration as a mechanism for cognitive development and highlighted verbal reasoning and discussion with peers who have different viewpoints with the aim of achieving a shared understanding. They had differing views on whether those groups should be like or unlike ability groups (Sills, Rowse, & Emerson, 2016). On certain tasks, discussion was very helpful to low-ability student groups and mixed student groups rather than same-ability groups (Sills, Rowse, & Emerson, 2016). There have been studies that have shown collaboration does not improve student achievement. Three of the studies reported a non-significant difference between students who worked in groups versus students who worked independently. Therefore, some critics argue that direct instruction from teachers is more beneficial to students. Introducing collaboration into the classroom can also pose challenges for the teacher.

Student collaboration defined. "Peer collaboration occurs when two or more peers work together on a collective task. They build a shared field of meaning linked to the resolution of a problem or collective activity" (Castellaro & Roselli, 2015, p. 64-65). Two other keys factors in collaboration per Castellaro and Roselli (2015) are the distribution of individual functions and the activity of each participant according to their individual role and integration of individual partial works and achievement of a collective product. Students, then, according to this definition work simultaneously and collectively on a subject or problem. They are no longer pursuing knowledge as an individual. Collaboration in a school is very interactive between students. They use whatever level of expertise they have to work with their peers to solve a common problem. Peer-based collaboration promotes the development of verbal, cognitive and social skills (Sills,

Rowse, & Emerson, 2016). Several schools are using Learning Communities with their students. Learning Communities put an emphasis on lifelong learning and students can involve more than just their peers (Bielaczyc & Collins, 1999). Community members and parents can use their levels of expertise to work together with students to problem-solve. The defining quality of a learning community is that everyone is involved, learning, and sharing their learning. Vygotsky said, "what a child can do in cooperation today the can do alone tomorrow" (Sills, Rowse, & Emerson, 2016, p. 322). Cicconi says that collaboration is a powerful tool that aids in deliberate decisions and forms effective strategies (Cicconi, 2014).

Characteristics of school-based collaboration. According to Bielaczyc and Collins (1999) there are four characteristics of learning communities: diversity of expertise among members, a shared objective of continually advancing the collective knowledge and skills, an emphasis on learning how to learn, and mechanisms for sharing what is learned. Communication skills are an essential part of collaboration. Students need to be able to learn from each other as well as teach one another. Collaboration needs to be a regular occurrence in classroom for a long period of time. Effective communication skills are important, and student must draw on each other's expertise (Paulsen, 2008). Groups can have from two to six students however three or four peers is optimal. The groups need to have enough students so there are several views and ideas circulating. It is also important that student be exposed to ideas and opinions different from their own (Sills, Rowse, & Emerson, 2016). The Association for Childhood Education International (ACEI) compiled a list of standards for educators. Five of the standards emphasize collaboration. In fact, the fifth standard is "Communication to foster collaboration - Candidates use their knowledge and understanding of effective verbal, nonverbal,

and media communication techniques to foster active inquiry, collaboration, and supportive interaction in the elementary classroom" (Cicconi, 2014, p. 57).

Implementing student collaboration groups. Teachers need to explicitly teach what collaboration looks like including respectful language and convey participation expectations. Just as teachers and company employees were trained to collaborate with each other, students need the same training. In one math classroom, students have a whole group discussion about the problem and various solutions. The teacher encourages students to discuss different ideas and solutions, so they develop a deeper understanding of the math they are working on. Participating in math discussions, learning how to make arguments, and learning mathematical language are central activities in the classroom (Bielaczyc & Collins, 1999). During that time, the teacher is making sure everyone is participating and asks questions to help students participate better. She also guides them and has explicitly taught how to participate efficiently and listen respectfully to other students. Communication is very important, and teachers need to teach students how to communicate respectfully. Creative thinking and collaboration skills are increasingly being recognized as some of the skills that separate students who are prepared or not for the ever more complex life and work environments in the 21st century (Fahnstrom, Prygrocki, & McLeish, 2009).

Critical Thinking Skills

One of the many things that teachers need to do to help their students be successful is to help them develop critical thinking skills. We need to better prepare our students to be part of the 21st century work force. Many researchers have said that we need to teach our students how to think not what to think. "It is no exaggeration to say that "critical thinking" has quickly evolved into a scholarly industry" (Weissberg, 2103, p. 317). Weissberg goes on to say that there are

more than 48,500 titles about critical thinking on Amazon (Weissberg, 2013). Currently, our education system is using mostly direct instruction which is more of a surface approach to learning rather than teaching for deep understanding. Today's students need to construct their own knowledge about a given topic while working collaboratively. They need to tackle problems that they may face in real life and persevere in solving them.

Critical thinking skills defined. Direct instruction tends to be focused on rote learning and memorization instead of on active engagement, critical thinking, application, and discovery-learning which results in students not learning the content as well as they could (Razzak, 2016). There are several definitions for what critical thinking skills are and there are several components of critical thinking. Students make meaning of things, usually with a group of peers, by observing, examining clues, and exploring possibilities. Working together they can solve problems by generating ideas and thinking creatively. Critical thinking skills are helpful in developing communication and collaborative skills as well. It often goes hand in hand with problem solving. Another article that says that critical thinking includes: brainstorming, creating new and worthwhile ideas, elaborating, refining, analyzing, and evaluating (Moeller, Cutler, Fielder, & Weier, 2013). They skills also include: developing, implementing, communicating new ideas, being open to new perspectives, incorporating group input into the work, demonstrating originality and inventiveness, understanding the real-world limits to adopting new ideas, and viewing failure as an opportunity to learn (Moeller, Cutler, Fielder, & Weier, 2013). Critical thinking allows students go beyond the information to figure things out for themselves (Razzak, 2016). It allows students to acquire facts and uncover deep meaning. Critical thinking has two components. The first is a set of information and belief generating and processing skills

and the second is the habit based on intellectual commitment, of using those skills to guide behavior (Weissberg, 2013).

Allowing students to connect deeply with the content is not an easy task. Teachers are struggling to cover more material, while class sizes are growing, and resources are limited. Then, there is the difficult process to trying to assess critical thinking skills. There is always a lack of time and training to learn the skills necessary to implement tasks, simulations, and projects that allow students to use higher-order thinking skills. Unfortunately, this is why teachers often resort to direct instruction methods such as lecturing. In a classroom that focuses on critical thinking skills, teachers are again in a facilitation role in the classroom. They are crucial in their students' success in critical thinking skills and deep learning (Razzak, 2016). It is important that teachers create safe, collaborative environments where students' responses are accepted by their peers and they are not afraid to fail. Specific guidelines need to be set about expected behavior and participation. Teachers need to pose open-ended questions, challenge students to support their thinking, and use supporting questions to help students dig deeper into the content. Teachers need to develop higher-order thinking activities and assessments for their students. They need to identify exactly which critical thinking skills students will use and communicate this to them, so they know what they are expected to do and know. Teachers can foster critical thinking of students through intellectual techniques like skilled questioning, coaching, re-directing and focusing (Razzak, 2016). In fact, Weissberg argues that teaching students to think critically should be the main focus of education (2013).

Critical thinking skills examples. It is important to look beyond the definitions and determine what critical thinking skills look like in the classroom. When students are using critical thinking skills they are using reasoning by making connections to previously learned

material and personal experiences. They are using systems thinking to analyze the problem. Students explore possible answers and come up with reasons for their answers. They practice making decisions by using their own ideas, evidence, and other people's perspectives. Students draw conclusions about their work after re-evaluating their ideas and collaborating with their peers (Moeller, Cutler, Fielder, & Weier, 2013). They are working and thinking to make their own, new knowledge. In addition, they are developing group work and teamwork skills.

We want student to think not just copy what has been modeled for them. Students are successful when they solve problems that have been modeled. They can also recite facts and recall information. When they are asked to apply the concepts that they have learned to new and unfamiliar situations they are usually unsuccessful (Razzak, 2016). Developing critical thinking skills will help students be more successful not only in school but throughout their lives. It will better prepare them for their future and better develop their 21st century skills.

Numbers Talks

Number talks are useful in the classroom for several reasons. They allow students to work together or collaborate and share math strategies. Number talks increase the number of strategies that students have to solve problems mentally. This helps students build confidence and communication skills. The Common Core and the Iowa Core both have standards that emphasize both procedural fluency as well as fact fluency. Doing calculations in your head not only keeps the basic arithmetic facts fresh but can also enhance understanding of mathematical concepts (Olsen, 2015). Olsen goes on to say, "Mental math methods help students understand mathematics. Mental math methods add connections in the brain that make homework easier and can help make new concepts easier to learn. Understanding occurs in the mind" (Olsen, 2015, p. 544). It is the teacher's role then, to help students attach meaning to the numbers through

thoughtful structuring to help student build their understanding about the mathematical properties and number relationships (Parrish, 2014).

Numbers talks defined. Mental computation is important not only because of its' usefulness in everyday life but because it is valuable in promoting higher-order mathematical thinking (Erdem, 2017). Number talks help students develop fluency with mental math. Mental math is associated with the ability to do math computation quickly and efficiently but, it is also associated with conceptual understanding and problem solving (Olsen, 2015). The teacher uses student-invented strategies to facilitate student thinking without telling the students how to solve the problems. The students' strategies give the teacher an opportunity to build number relationships and mathematical ideas (Parrish, 2014). All of the students' strategies are accepted by the teacher even if they have an incorrect answer. Student then, develop different strategies that they can then transfer to more complex math problems.

Number talks advantages. One of the advantages of using number talks in the classroom is that they reduce the working memory load which allows students to focus on more complex math problems and strategies. Building students' fluency through number talks can allow them to build flexible, transfer knowledge about numerical symbols and the quantities they represent (Liu, Kallai, Schunn, & Fiez, 2015). Using number talks encourages students to develop a connection to the relationship with numbers. Students are encouraged to consider the meaning of numbers and quantities within a problem, as opposed to just following a set of procedures without thinking about what they are doing (Liu, Kallai, Schunn, & Fiez, 2015). Mental computation has also been associated with improved number sense.

Number talks examples. Sherry Parrish is the author of two books of number talks for kindergarten through high school. The third-grade number talks develop fluency and allow

students to share strategies for both addition and subtraction. Some examples of number talks are centered around: making tens, making landmark or friendly numbers, doubles and near doubles, breaking numbers apart, adding up in chunks, adding up, removal, place value and negative numbers, adjusting one number, and keeping a constant difference (Parrish, 2014). Students would share strategies they used and the reasoning behind those strategies. Students have the opportunity to agree or disagree and share their own ideas. After the small group discussion, whole group discussion serves to hear from students and allow them to learn from each other by sharing what strategies they used.

Methods

Participants

For this action research the participants are twenty-three, third grade, general education students. The students are at various academic levels. One student is in special education and has an Individualized Education Plan (IEP) for reading. Three students are in the Extended Learning Program (ELP) for math. The students are eight and nine-year old's, ten are boys and thirteen are girls.

The pre-intervention data was collected while students were sitting is rows and working primarily independently. Students were prepared for the intervention after the first set of data was collected. Students were placed in collaborative groups of three or four students per group and were taught how to work in those groups. They were taught participation rules as well as respectful language to use while working in their groups They practiced for three weeks prior to the post assessment data being collected.

Data Collection

For this research six data points were collected. Three data points were collected prior to the intervention and three after. Six assessment were created with similar problems and graded on accuracy. They problems were grade on correctness and problems were given a value of one point each. The assessments were real-world or story problems which students could solve using strategies of their choice. The problems were both addition and subtraction involving three- and four-digit numbers.

Three of the assessments were given once a week for three weeks. The following three weeks were dedicated to learning how number talks work and practicing the process in the classroom. Following the three weeks, three additional assessments were given once a week for three weeks. The total time for the study was nine weeks. Students were graded based on accuracy. Multiple strategies were accepted. Students were allowed to draw pictures, use different addition and subtraction strategies, as well as the standard algorithm.

Students were set up in peer learning communities for the intervention. They were set up in mixed ability groups. Although, they are all general education students, group were composed of higher and lower ability students. They practiced collaboration in groups and came up with group norms for their teams. They learned respectful communication and participation. Student were given sentence starters such as, “I agree with student A because” or “I disagree with student A because.” They learned how to work together in their collaborative groups. The goal was to help them develop a sense of community within their groups. When they had a good understanding of the process of collaboration, Number Talks were introduced. They were showed slides that had four addition problems and were given a short amount of time to use their mental math strategies to solve the problems. They were then given group time to share their strategies with their group members. Finally, the collaborative groups shared strategies with the

whole class in large group discussion. Each number talk lasted approximately twenty minutes and several slides were shared during this time. After several number talks students started using their new strategies throughout the entire math class.

Results

Table 1 shows student data from the first three assessments. These assessments had three addition and subtraction real world problems per assessment. The assessments were given at three different times one week apart. The three scores were then averaged to give the student one overall score prior to the Number Talks intervention.

Table 1

Pre-intervention assessment data

	Assessment 1	Assessment 2	Assessment 3	Student Average
Student A	67	50	50	56
Student B	67	100	67	78
Student C	100	83	100	94
Student D	50	83	83	72
Student E	50	100	83	83
Student F	50	67	50	57
Student G	83	83	67	78
Student H	83	100	67	83
Student I	83	100	100	94
Student J	83	100	100	94

Student K	33	100	67	67
Student L	67	83	67	72
Student M	50	100	83	78
Student N	50	100	83	78
Student O	100	100	67	89
Student P	33	67	67	56
Student Q	50	100	83	78
Student R	67	83	67	72
Student S	67	83	83	78
Student T	83	83	100	89
Student U	83	83	67	78
Student V	50	83	67	67
Student W	33	100	67	67
Class Average	65	88	75	76

The class average for the first assessment was 65%. Eight students scored above 80%. Ten students scored below 60%. Five students scored between 60-79%. The second assessment had the same number and types of problems. For the second assessment twenty students scored above 80% and only three below. Only one of those students scored 60% or below and two scored between 60-79%. Giving the class an average of 88%. The third assessment results showed ten students scored above 80%, eleven students scored between 60-79% and two students scored below 60%. The class average for the third assessment was 75%. Averaging those three scores the pre-intervention data showed seven students were at 80% or higher prior to the intervention. Thirteen students were between 60-79% prior to the intervention. Three

students were below 60% prior to the intervention. The overall class average on the three assessments was 76%.

Table 2 shows student data from the last three assessments. These assessments had three addition and subtraction real world problems per assessment. The assessments were given at three different times one week apart. The three scores were then averaged to give the student one overall score after the number talks intervention.

Table 2

Post-intervention assessment data

	Assessment 1	Assessment 2	Assessment 3	Student Average
Student A	67	100	100	89
Student B	100	100	75	92
Student C	100	100	100	100
Student D	0	60	100	53
Student E	0	80	100	60
Student F	67	60	75	67
Student G	100	60	100	87
Student H	100	100	100	100
Student I	100	100	100	100
Student J	100	100	100	100
Student K	100	100	100	100
Student L	100	80	75	85
Student M	100	100	75	92

Student N	100	100	100	100
Student O	67	100	100	89
Student P	67	80	75	74
Student Q	33	100	100	78
Student R	33	60	100	64
Student S	67	60	75	67
Student T	100	100	100	100
Student U	100	100	100	100
Student V	100	80	100	93
Student W	100	100	100	100
Class Average	78	88	93	87

The class average for the first assessment was 78%. Fourteen students scored above 80%. Four students scored below 60%. Five students scored between 60-79%. The second assessment had the same number and types of problems. For the second assessment eighteen students scored above 80% and no students scored below 60%. Five students scored between 60-79%. Giving the class an average of 88%. The third assessment results showed seventeen students scored above 80% and five students scored between 60-79%. No students scored below 60%. The class average for the third assessment was 93%. Averaging those three scores the post intervention data showed sixteen students were at 80% or higher after the intervention. Six students were between 60-79% after the intervention. One student was below 60% after to the intervention. The overall class average on the three assessments was 87%.

Table 3 shows the percentage of increase or decrease found between the pre-assessment and post assessment data. The student averages from the pre and post intervention data were used to calculate the change in student performance.

Table 3

Pre and post-intervention assessment data

	Pre-assessment	Post assessment	% Change
Student A	56	89	58.92
Student B	78	92	17.94
Student C	94	100	6.38
Student D	72	53	-26.38
Student E	83	60	-27.71
Student F	57	67	17.54
Student G	78	87	11.54
Student H	83	100	20.48
Student I	94	100	6.38
Student J	94	100	6.38
Student K	67	100	49.25
Student L	72	85	18.05
Student M	78	92	17.95
Student N	78	100	28.21
Student O	89	89	0.00
Student P	56	74	32.14

Student Q	78	78	0.00
Student R	72	64	-11.11
Student S	78	67	-14.10
Student T	89	100	12.36
Student U	78	100	28.21
Student V	67	93	38.81
Student W	67	100	49.25
Class averages	76	87	14.47

The class as a whole had an average increase of 14.47% from the pre-assessment to the post assessment. Seventeen students showed an increase. Three students had an increase in scores of between 6-10%. Two students had an increase of 11-15%. Four students had an increase of 16-20%. One student had an increase of 20-25% and seven students had an increase of 25% or higher. Four students had a decrease. The decrease ranged from just over 11% to almost 28%. Two students' scores remained the same showing no improvement between the pre and post assessment data.

Discussion

This study explored how students working in collaborative, student-centered groups can have a positive effect on student problem-solving skills. The results of this study show a significant increase in student scores from the pre to the post assessment data. Students were placed in collaborative groups and given an opportunity to work together to improve the efficiency and the number of strategies that they should use to solve math problems. Students learned to use respectful language while working with their partner groups. Students also developed good communication skills and were able to use those skills to teach each other their

math strategies. They showed that they could take ownership of their learning. They were teachers and learners throughout this process and constructed and shared their own knowledge. Students who collaborate with their peers are not only gaining important mathematical skills but are also developing 21st Century skills. The expectations need to be explicitly taught to students about the distribution of functions in the group, respectful language and how to work collectively on a problem simultaneously. Teachers can use this as an opportunity to promote relationships between peers and provide support and guidance to unsure student success. The development of student critical thinking skills is becoming more important in classroom. Teachers need to prepare their students to do jobs that haven't even been invented yet. Helping students develop critical thinking skills that can be used beyond school is an important task of teachers. Using guiding questions instead of direct instruction can help students become more successful in developing those skills.

Summary of Findings

Seven students were proficient prior to the intervention. Sixteen students were proficient after the intervention. Nine additional students were successful solving real-world problems after the intervention. Thirteen students scored between 60-79% prior to the intervention and six were still in that category after the intervention. Three students were below 60% prior and only one student was below 60% after the intervention. Six students were proficient in both data sets. Ten students improved in the second data set to become proficient. In total seventeen students showed improvement after the Number Talks intervention. These finding suggest that the collaboration did make students more effective problem solvers. Working with peers appears to have increased critical thinking skills and provided students with more problem-solving strategies. Students were able to deepen their understanding of the content by interacting with

their peers in student-centered collaboration (Lee & Hannafin, 2016). Two of the students who were below proficiency still showed growth between the two data collection points. The findings suggest that because seventeen students showed improvement the group work helped students support each other's learning and showed that they could work together with a single purpose (Calder, 2015). As Bielaczyc and Collins expressed, there are four characteristics that a collaborative culture must have: diversity of expertise among its members, a shared objective, an emphasis of learning how to learn, and a way to share what is learned (1999). All four characteristics were implemented in student groups. The groups academic levels were mixed, they had a shared objective of accurately solving problems and sharing the strategies that they used. They were taught how to teach each other by explaining their strategies and were taught how to share what they had learned by communicating effectively with each other. The increase in the scores suggests that implementing a student-centered, collaborative classroom did improve students critical thinking and problem-solving skills.

Teacher facilitation in the classroom appears to have been effective. The role of lecturer was changed to that of encouragement and engagement. Through questioning and providing prompts to assist student participation students were able to develop multiple strategies and take ownership of their learning. Students were able to communicate strategies effectively and increase their own learning and critical thinking skills. Participating in math discussions, learning how to make arguments, and learning mathematical language are central activities in the classroom (Bielaczyc & Collins, 1999).

Limitations

There are several factors that could have affected the results of this action research. The first set of assessments were administered early in the school year. Students could have been adjusting being back at school and to their new classroom. Students may have needed more

review of addition and subtraction skills prior to the data collection. The second set of assessments were similar in difficulty to the first set and students may have been more accurate because they had been practicing similar problems for nine weeks. The amount of time for the study was limited therefore, furthermore research need to be done to better establish the results. This study lasted nine weeks and a longer study would have provided more data. Paulsen stated that effective school-based collaboration must be sustained over time (2008). She further explained that effective communication skills are essential, and students must draw on each other's expertise. (Paulsen, 2008). Using a larger group of participants would have provided more data and more results.

Further Study

Future research questions could focus on how many strategies students used prior to the intervention and after to determine if the number of strategies they were using increased. Also, studying whether or not their strategies became more efficient throughout the study would help to determine if critical thinking skills actually increased.

Conclusion

Teachers should set high expectations for their students to achieve the highest levels. Their job is to prepare students for a life beyond the classroom. Teachers need to be a facilitator of their students' learning. Students need to construct their own knowledge about a given topic while working collaboratively. They need to tackle problems that they may face in real life and persevere in solving them. Working in student-centered collaborative groups can improve communication skills, social skills, and help student become more confident. They can develop multiple problem-solving strategies to help them be successful in the classroom and beyond. Two other keys factors in collaboration per Castellaro and Roselli (2015) are the distribution of

individual functions and activity of each participant according to their individual role and integration of individual partial works and achievement of a collective product. Students can develop a sense of community in their collaborative groups and this can help them not only take ownership in their learning but develop multiple strategies and reasoning skills to make them more successful in the classroom.

Given the results of this research, the question: will implementing a student-centered, collaborative classroom improve students' problem solving and critical thinking skills, has been addressed and shown to be a successful method of education in the classroom. Using student-centered collaborative classrooms can help students achieve at high levels and develop the confidence to be successful in the classroom and beyond the classroom. Students can strengthen the understanding of mathematical concepts and take ownership of their learning.

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